BIOLOGICAL SURVEY OF THE MOIRA RIVER

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Ministry of the Environment

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SUMMARY AND CONCLUSIONS

A biological survey was carried out between July 17 and August 10, 1967, to evaluate water quality in the Moira River and major tributaries and to assess the effects of specific industrial and domestic waste discharges on aquatic biota. Major sources of pollution include arsenic contamination originating from the Deloro Smelting and Refining Company, Limited at Deloro, cooling water and process wastes from the H. Corby Distillery, Limited at Corbyville and partially-treated domestic wastes from the villages of Tweed and Madoc.

Bottom fauna and water for routine chemical analyses were collected at 46 river stations and at a total of 38 stations on Moira Lake and Stoco Lake. Arsenic determinations were performed on samples of water and sediment collected from above Deloro downstream to Stoco Lake and on samples of game fish obtained from Moira Lake.

Mean concentrations of arsenic in water samples collected from the river below Deloro and from Moira Lake were 0.28 ppm and 0.16 ppm, respectively, whereas no arsenic was detected in samples taken upstream of Deloro. Other studies have revealed a substantial decrease in these concentrations since 1958 which can be attributed largely to control measures implemented by the company, including collection of contaminated surface runoff from the property and removal of arsenic by chemical precipitation. Nevertheless, concentrations below Deloro are consistently higher

than those above Deloro and represent significant contamination in view of the Commission objective of 0.05 ppm.

While concentrations of arsenic in river sediments were considerably lower in 1967 than in 1958, lake sediments showed a significant increase in mean concentrations from 26 ppm in 1958 to 437 ppm in 1967. Also, arsenic concentrations appeared to have become more widely distributed in the system, extending downstream into Stoco Lake (mean concentration in sediments of 85 ppm at four stations) in 1967, whereas no arsenic was detected in sediments of the eastern basin of Moira Lake in 1958. These findings illustrate the potential hazard associated with the build-up of arsenic in the two lakes and the corresponding protection afforded the downstream section of the Moira River.

Arsenic levels were found to be consistently higher in predominantly organic sediments suggesting uptake by aquatic biota. While this was not examined in detail, a cursory evaluation of levels in perch, bass and walleye revealed a mean concentration of 0.28 ppm in whole fish and 0.06 ppm in flesh.

A restriction in the diversity and abundance of bottom fauna communities throughout approximately five miles of river below Deloro was attributed to arsenic toxicity. Adverse effects of arsenic on bottom fauna communities further downstream were not demonstrated.

Although further control measures to contain arsenic-bearing waste materials on the property at Deloro should result in acceptable levels downstream in the river, the possibility of re-contamination of lake water from arsenic contained in sediments and long-term detrimental effects on bottom organisms and other aquatic biota must be recognized.

The levels of arsenic noted in the water and fish of Moira Lake raise the question of their suitability for human consumption. Although the possibility of acute toxic effects seems remote, in view of the relatively low recognized desirable limit of 0.05 ppm arsenic for drinking water the extent of use of the water of Moira Lake for drinking purposes by cottagers and resort owners and the utilization of game fish warrant further investigation by health authorities.

Sanitary wastes from Madoc adversely affected bottom fauna communities of Deer Creek for a short distance below the discharge. Biological and chemical parameters showed almost complete assimilation of wastes within the creek, with only slight effects on a localized portion of the western basin of Moira Lake near the mouth of the stream. Coliform contamination persisted downstream only to the mouth. Chemical characteristics and bottom fauna communities were similar in the western and eastern basins of Moira Lake. Populations at all stations in the littoral region of the lake were diverse but at deeper stations were

comprised only of organisms capable of withstanding low concentrations of dissolved oxygen. Depletion of dissolved oxygen at deeper stations was confirmed and was attributed to weak thermal stratification in conjunction with high benthic oxygen demand associated with the decomposition of aquatic vegetation rather than sources of waste inputs.

Physical, chemical and biological characteristics of Stoco Lake were similar to those of Moira Lake. Normal bottom fauna communities were present in the littoral region. Chemical parameters were uniform throughout Stoco Lake and indicated no significant adverse effects from sanitary waste discharges at Tweed. However, serious coliform contamination was evident at stations in the vicinity of Tweed and in recent years this condition has resulted in the frequent closure of the public bathing beach at Tweed by local health authorities. Dissolved oxygen depletion and related changes in the bottom fauna communities was noted in the deepest portion of the lake and was attributed to natural factors as described previously for Moira Lake.

Blue-green algal blooms of nuisance proportions have occurred frequently during recent years in Moira Lake and Stoco Lake indicating, along with the results of this survey, the extremely productive and eutrophic condition of these waters. While enrichment from sanitary wastes has undoubtedly contributed to lake fertility, natural factors are probably of greater importance in determining productivity levels. Yields of nitrogen and phosphorus (the major

limiting plant nutrients) from sanitary wastes were demonstrated to be insignificant relative to yields which could be expected to occur in natural runoff from the watershed. Consequently, a reduction of inputs of plant nutrients from artificial sources could not be expected to substantially reduce existing levels of primary production.

Thermal and organic pollution of the Moira River by the H. Corby Distillery at Corbyville adversely altered bottom fauna populations and promoted abundant growths of 'sewage slimes' along the east shore of the river for a distance of approximately 1200 feet below the discharge. At this point recovery was nearly complete and bottom fauna reflected unimpaired water quality at a point one mile below the discharge. Chemical parameters were not altered, probably owing to high flows at the time of the survey. Elevated levels of plant nutrients probably accounted for the excessive production of aquatic vegetation, particularly filamentous algae, noted in the impounded portion of the river at Cannifton.

The only other evidence of pollution detected in this survey was an extremely high coliform count in a sample taken from Jordan Creek below the village of Millbridge. Biological and chemical parameters examined on other tributaries and reaches of the Moira River revealed water of excellent quality.

Recommendations

1. Further studies to delineate sources of arsenic contamination and further control measures are required to ensure that arsenic concentrations downstream of Deloro meet the objective of 0.05 ppm and permit the normal propagation of aquatic life.

2. Chemical and biological studies should be continued to monitor levels of arsenic in water, sediment and aquatic biota downstream through Stoco Lake and to assess the possible significance of arsenic accumulations in lake sediments.

3. Improved treatment of domestic wastes at Madoc and Tweed, including adequate chlorination, is required to protect water quality in Deer Creek, Moira River and Stoco Lake.

4. Plans submitted by the H. Corby Distillery Limited for the treatment of cooling water and process wastes have now been approved and should lead to improved water quality. Chemical, biological and aesthetic characteristics of the river below Corbyville should be assessed in future surveys.

5. Investigations should be carried out to determine the source(s) of coliform contamination of Jordan Creek below Millbridge and necessary corrective measures should be implemented.

BIOLOGICAL SURVEY OF MOIRA RIVER

INTRODUCTION

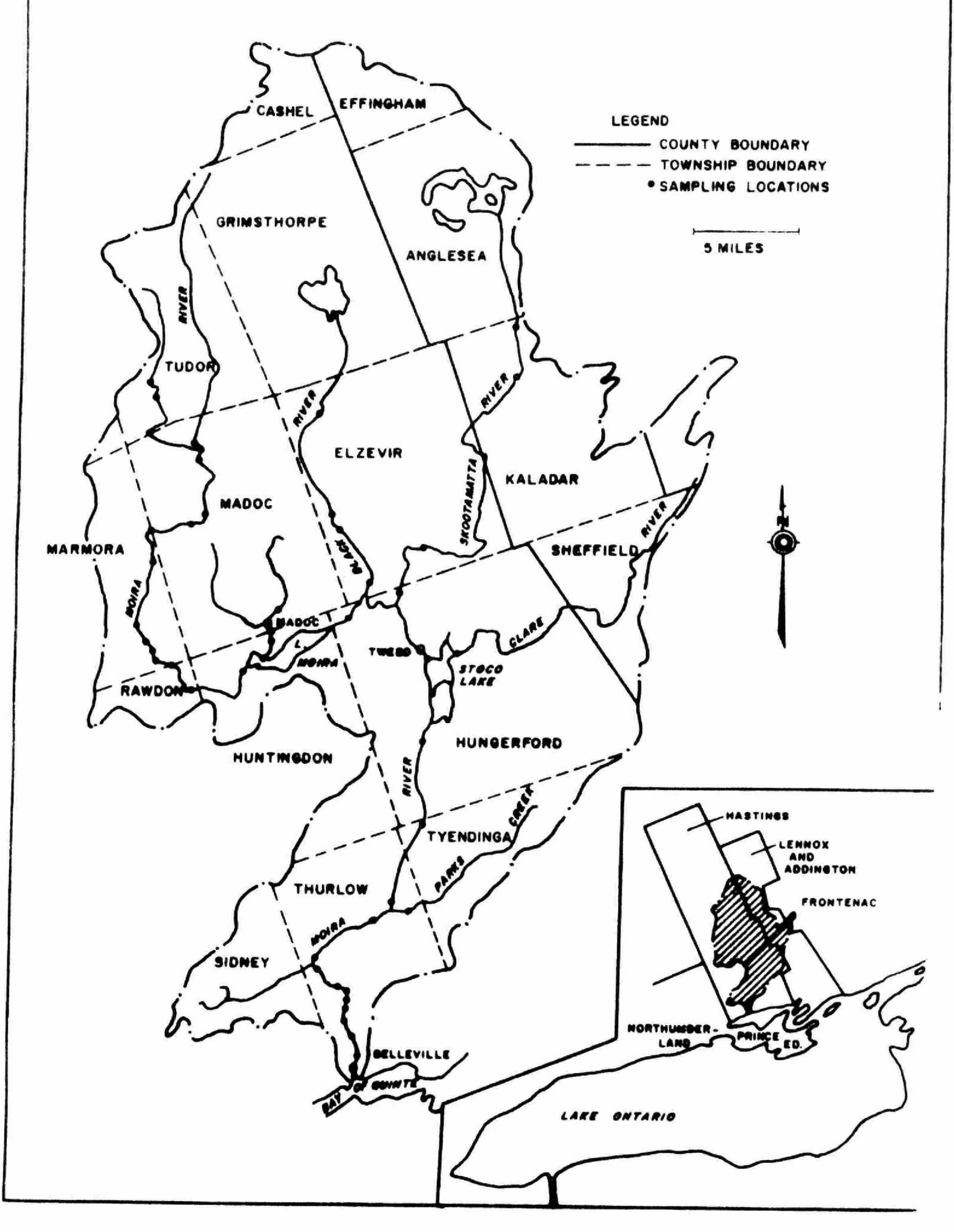
Previous surveys by the Ontario Water Resources Commission have drawn attention to pollution of the Moira River from domestic and industrial waste discharges. Of major importance have been the long-term arsenic contamination of the upper watershed originating at Deloro, domestic waste discharges from the villages of Madoc and Tweed, and thermal and organic pollution of the river by the H. Corby Distillery Limited at Corbyville.

A biological survey of the Moira River was undertaken in August of 1967 to further evaluate the effect of these wastes sources on water quality and aquatic biota of the river. Also included was an examination of the water quality of the major tributaries and other reaches of the Moira River to define existing conditions and to provide a baseline for future comparative purposes.

DESCRIPTION OF THE WATERSHED

The Moira River drains an area of 1056 square miles of Hastings County and portions of Lennox and Addington and Frontenac counties, emptying to the Bay of Quinte on the north shore of Lake Ontario (Figure 1).

FIG. I MOIRA WATERSHED



The three main branches of the Moira River - the upper Moira, Black and Skootamatta - have their origin in the northern sector of the watershed and flow in a southerly direction. South of highway #7, the upper Moira flows easterly and widens to form Moira Lake (Figure 2). From Moira Lake the river continues in an easterly direction to its confluence with the Black and Skootamatta rivers. The combined flows enter Stoco Lake (Figure 4) as does the Clare River, which drains the north-eastern portion of the watershed. The Moira emerges from Stoco Lake in two channels which converge about two miles further south. The river then pursues an irregular southerly course to the City of Belleville where it empties into the Bay of Quinte.

Gradients on the Moira River and its tributaries are comparatively steep; the main river falls an average of 9.32 feet per mile over its 91.6 mile course and the average gradients on the Black and Skootamatta are 17.5 and 16.1 feet per mile, respectively. River flow is characterized by rapids and occasional waterfalls interspersed with wide quiet channels. Streamflows, in cubic feet per second, for the period 1961 to 1965 and the year ending Sept. 30, 1967 are summarized below.[1]

		Mean monthly flow (cfs)				Mean flow
		1961-1965		1967		survey period
Watercourse	Guage	Max.	Min.	Max.	Min.	1967
Black	Actinolite	498	26.9	531	9.6	69.8
Skootamata	"	849	8.9	1100	43.0	114
Upper Moira	Deloro	-	-	485	0.7	25.4
Moira	Foxboro	3158	56.3	3710	53.6	474

1 Data were obtained from published records for the period 1961 to 1965 and from provisional records for the year 1967 of the Water Resources Branch, Dept. of Energy, Mines and Resources.

In most years low flows occur in August and may extend through November. During the survey period, however, flows were considerably higher than the average monthly low flow for most years.

The portion of the watershed lying north of Moira and Stoco Lakes is comprised for the most part of exposed Precambrian granite. This area has tended to be more important for mining and lumbering than for agricultural pursuits and the region is still sparsely populated.

The southern third of the watershed consists of a wide variety of post-glacial land forms with agriculture being the predominant land use. The main product is milk, but mixed farming and beef farming are also important. Major urban centres are located in the southern section of the watershed including the City of Belleville (pop. 32,627) and the villages of Madoc (pop. 1,312) and Tweed (pop. 1,713).

A number of smaller unincorporated communities exist and those which are situated on major watercourses are shown in Figures 2 and 6.

WATER USES

Water Supply

The H. Corby Distillery obtains its water supply from the Moira River at Corbyville. Cottagers and camp owners on Moira Lake utilize lake water for drinking and domestic purposes.

Waters of the lower Moira watershed are used to some extent for crop irrigation and watering livestock.

Recreation

Recreational use of the Moira watershed is of prime importance. Owing to the predominantly rural nature of the watershed there are numerous recreational sites and it has some of the most attractive scenery in Southern Ontario. Many summer residences, camping grounds and picnic sites are present, especially on Moira Lake and Stoco Lake. These lakes, as well as the river itself, are popular for boating and swimming. Moira Lake, alone, has approximately 300 cottages along its shoreline.

Sports Fishing

The Moira River watershed provides quality angling both with respect to catch returns and the diversity of species taken. Moira Lake provides excellent fishing for walleye, smallmouth bass and perch, while Stoco Lake supports muskellunge in addition to the aforementioned species. Eight tourist establishments are located on Moira Lake and two on Stoco Lake, which are substantially dependent on angling clientele for their successful operation.

Waste Disposal

Major industrial waste inputs originate from the Deloro Smelting and Refining Company at Deloro and the H. Corby Distillery at Corbyville. Although the Deloro Smelting and Refining Company ceased operations in 1961, there

has been a long history of arsenic contamination of the Moira River as a result of leaching and runoff from arsenic-containing materials deposited on the site. By 1966 the company had provided facilities for the collection and impoundment of run-off and the chemical precipitation of arsenic. A monitoring program initiated in 1958 has revealed a substantial reduction in arsenic concentrations in the Moira River below Deloro (3).

In 1967, the Division of Industrial Wastes reported a known loading of two pounds of arsenic per day from collected surface drainage. However, on the basis of concentrations observed in the river, total yields from the site have been considerably greater, probably as a result of contaminated groundwater sources.

The H. Corby Distillery discharges a volume of 2.4 million gallons per day of heated waste containing 1500 pounds of BOD_5 and 650 pounds of suspended solids. Net yields of total Kjeldahl nitrogen are 40 pounds per day and total phosphorus in the waste is somewhat less.

EXPLANATION OF BIOLOGICAL EVALUATION

Under natural conditions, aquatic plant and animal communities are comprised of a multiplicity of species

adapted to various environmental factors and existing in a relatively balanced state. Changes in physical and chemical characteristics of a watercourse eliminate the more sensitive species and disrupt the natural balance. The biological assessment of water quality is based on an examination of the relative composition and abundance of tolerant and intolerant species; the degree of upset of the biological balance, in turn, reflects the degree to which properties of the water have been changed. In addition, biological parameters provide direct evidence of damage to the usefulness of a watercourse resulting from pollution. Alterations in plant and animal communities often adversely affect the amenities, recreational potential, self-purification capacity and general usefulness of a watercourse.

Physical and chemical data are complementary to biological data in that they permit interpretations of observed changes in the biota and place the evaluation of pollution in terms amenable to solution.

In the present study emphasis was placed on the examination of bottom fauna communities. Species within this group exhibit a wide range in tolerance to various pollutants and because of relatively long life cycles, usually up to a year or more, they reflect water quality conditions over a considerable period prior to the survey. Under natural conditions, communities are characterized by a wide diversity of species with low numbers of each. Organic pollution greatly reduces the number of species and supports high numbers of those organisms capable of withstanding low

concentrations of dissolved oxygen. Toxic pollutants usually restrict bottom fauna communities in both diversity and total numbers.

METHODS

Arsenic Content

Arsenic determinations were made on samples of water and sediments collected at each station from above Deloro downstream through Stoco Lake. A 4-ounce volume of sediment was taken from the top inch of undisturbed dredge samples, air-dried at room temperature and stored for subsequent analysis at the laboratory. Arsenic determinations were performed on water samples collected for routine chemical analyses.

Also, analyses of arsenic in game fish, including smallmouth bass, *Micropterus dolomieui*, yellow perch, *Perca flavescens*, and walleye, *Stizostedion vitreum*, were performed on specimens obtained from anglers on Moira Lake. Fish were weighed, scale samples secured and total lengths determined. Analyses were made on gonads, liver, skin, muscle and whole fish following freezing and storage for approximately three months.

Water Chemistry

Water samples were taken from the surface at each stream station and from a foot off bottom at selected lake stations by means of a Kemmerer depth sampler.

Determinations for BOD, total and dissolved solids, total phosphorus, nitrogen fractions, pH, hardness, alkalinity, arsenic and coliform densities were performed at the laboratory according to Standard Methods. Both pre-dawn and mid-day dissolved oxygen determinations were made in the field (azide modification of the Winkler method). Determinations were made at river stations below known sources of organic wastes and on top and bottom water samples from selected lake stations.

Bottom Fauna

Bottom macroinvertebrates were collected at 46 river stations and at a total of 38 stations on Moira Lake and Stoco Lake during the survey period between July 17 and August 10, 1967. Locations of the survey stations on the Moira River and its tributaries are shown in figures 1, 2 and 5. Figure 6 shows the locations of stations sampled in October, 1968, to examine in greater detail the effects of industrial waste discharges at Corbyville.

Wherever possible, macroinvertebrates from stream stations were collected from a riffle habitat using a 20-mesh-per-inch hand sieve. Ten minutes of uniform effort were employed to sample all common habitats at these stations. Where riffle habitat was absent (stations ME1, M13, MD4, MS4, MC1, M22, M30) five samples were obtained using a 6x6 inch Ekman dredge, which were then composited. Similarly a 9x9 inch Ekman dredge was used to sample the bottom fauna of Moira and Stoco lakes. Dredge contents were washed through a 24-mesh-per-inch (0.0125 inch openings) sieve and organisms

were separated from extraneous material. All collections were preserved with ethanol and returned to the laboratory for subsequent identification and enumeration. Stations M4 on the Moira River and station 4 on Moira Lake were omitted.

Observations of physical factors affecting the distribution of bottom fauna were noted and sediments were classified (sand, silt, clay, etc.) visually in the field.

RESULTS

Arsenic Contamination

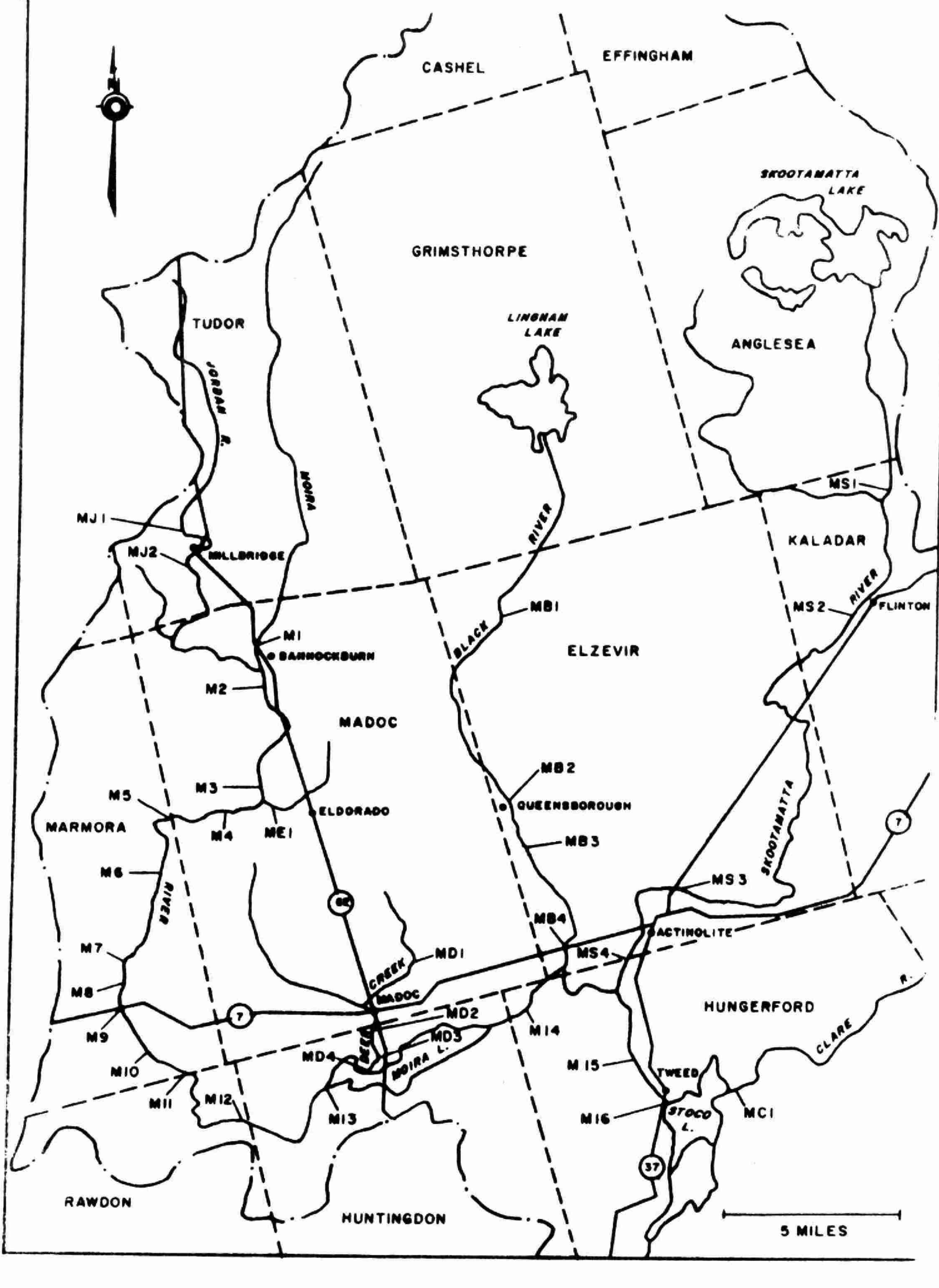
Arsenic in Water

Concentrations of arsenic in water and sediment samples collected at stations upstream and downstream of the Deloro Smelting and Refining Company are shown in Table 1. Station 8b was located approximately 200 feet below the known sources of arsenic contamination while station 7, located upstream of the company property, served as a control.

No arsenic was detected in river water upstream of Deloro, whereas a mean concentration of 0.32 ppm was detected at five river stations below Deloro with levels at each station exceeding the Commission's objective of 0.05 ppm.

In conjunction with surveys carried out by the Division of Industrial Wastes, arsenic determinations have been made on a series of 12 to 18 samples collected each year since 1958 at a control site upstream of Deloro and downstream at Highway #7 (8). These data have revealed a general decreasing trend

FIG. 2 UPPER MOIRA WATERSHED



in mean concentrations at Highway #7 from 37.5 ppm in 1958 to 0.50 ppm in 1967. Concentrations upstream of Deloro, which represent for the most part arsenic of natural origin, exceeded the objective of 0.05 ppm only during periods of extremely low flow.

Table 1. Concentration of arsenic (expressed as ppm As) in water and sediments at selected stations on the upper Moira River, 1967

Station	Water	Sediment	Sediment description
MJ2		trace	sand
M3		trace	sand
ME1		0	sand
M5	0.00		
M6	0.00		
M7	0.00		
M8b	0.38	0	sand
M9	0.22	120	sand
M10	0.57		
M11		870	sand, silt
M12	0.19	700	gravel
M13	0.26	50	sandy silt
M14	0.06		
M15		trace	sand, gravel

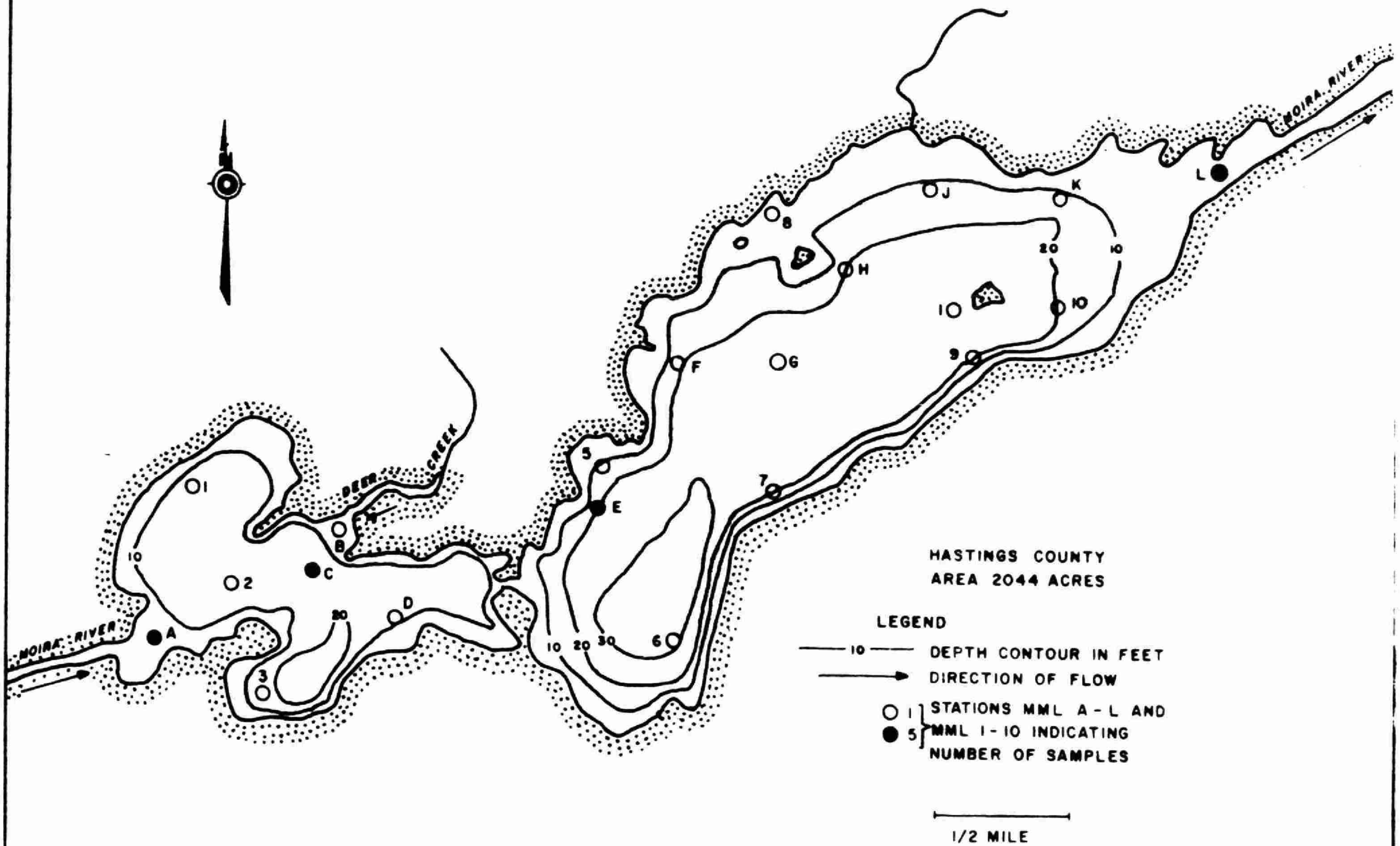
Data collected for arsenic in the water of Moira Lake are presented in Table 2. Concentrations were somewhat lower than in the river, averaging 0.16 ppm at twelve stations. Levels were relatively uniform between

Table 2. Concentrations of arsenic (expressed as ppm As) in water and sediment samples from Moira Lake in August of 1967, 1963 and 1958.

Stations	Water			Sediment			Sediment description	
	1967	1963	1958	1967	1963	1958	1967	1963
A	0.17	0.10	4.8	700	250	100	Si	
B	0.22	-	-	-	-	-		
C	0.17	0.10	-	-	500	-		
D	0.12	0.05	1.2	1000	400			
1	-	-	-	190	-	-	SaSi	
2	-	-	3.2	-	-	4		
3	-	-	-	590	-	-	Si	
E	0.12	0.02	0.40	-	-	0		
F	0.20	0.02	-	280	100	-	Si	Si
G	0.13	0.08	-	430	100	-	Si	Si
H	0.17	0.08	-	380	30	-	Si	Si
I	0.23	0.05	-	580	180	-	Si	Si
J	0.15	0.04	-	96	-	-	SiSh	GrSh
K	0.14	0.04	-	-	20	-		SiClSh
L	0.14	0.04	-	-	180	-		ShD
5	-	-	-	180	-	-	SiSh	
6	-	-	-	800	-	-	Si	
7	-	-	-	120	-	0	Si	
9	-	-	-	430	-	-	Si	
Average	0.16	0.06	2.4	437	196	26		

Si=silt, Sa=sand, Sh=shells, Or=organic matter, D=debris, Cl=clay
Gv=gravel

FIG. 3 MOIRA LAKE



stations and similar in each basin of the lake. Table 2 also provides a comparison of arsenic concentrations in Moira Lake water in 1967 with those found in surveys carried out in August of 1958 and 1963, which shows a decrease similar to that noted in the river. This was true particularly for the western basin of the lake. While levels at all stations on one sampling occasion in 1967 were higher than in 1963, it is not certain that this represents a significant increase in view of known seasonal variations and the overall downward trend in concentrations for both the lake and the river since 1958.

Arsenic in Sediments

Appreciable concentrations of arsenic were found in river and lake sediments from Deloro downstream to Stoco Lake (Tables 1, 2 and 3).

Table 3. Concentrations of arsenic in sediments of Stoco Lake.

Station	Arsenic in sediment as As ppm	Sediment description
C	trace	sand
E	85	sandy silt
5	220	sandy silt
10	120	sandy silt
MC1	trace	sand

At stations on the main river and tributaries upstream of Deloro, sediments contained only trace amounts. At station 8b immediately below the company site, no arsenic was detected in sediments but further downstream levels reached a high value of 870 ppm at station M11. These concentrations, however, were considerably lower than those found in this section of the river in the August, 1958 survey, at least on the basis of two comparisons - 1830 ppm at station 9 and 430 ppm at station 13 in 1958 as compared to 120 ppm and 50 ppm in 1967. In contrast, the arsenic content in sediments of Moira Lake and perhaps Stoco Lake has increased substantially over the same period (Table 2). Values were highest in the western basin of Moira Lake in all years with a maximum concentration of 1000 ppm occurring at station D in 1967. There is no previous information on arsenic content of Stoco Lake sediments but it would be reasonable to assume its absence in 1958 considering that no arsenic was found in sediments of the eastern basin of Moira Lake at that time.

The drastic reduction in arsenic content of river substrates, together with the increase and wider distribution in lake sediments, suggests a downstream translocation of arsenic tied up in the bottom materials. The importance of the lake environment in removing arsenic from the system through sedimentation of insoluble arsenic or biological cycling was further demonstrated by the relatively low levels in river water and sediments below Moira Lake and the subsequent reappearance of high levels in bottom materials of Stoco Lake.

It must be recognized that a possible relationship exists between the increased levels of arsenic in the sediments of Moira Lake and the higher levels found in the water in 1967, as compared to 1963.

Arsenic in Fish

Data presented in Tables 1, 2 and 3 reveal a trend towards higher levels of arsenic in predominantly organic sediments (reported as silt on the basis of particle size) indicating significant accumulations in settled plankton and other aquatic organisms. Therefore, fish would be expected to accumulate arsenic by transfer through the food chain. In view of the excellent sport-fishery in Moira Lake, the arsenic levels in game fish were examined. Results of a preliminary nature for bass, perch and walleye are summarized in Table 4.

Table 4. Mean concentrations of arsenic (As) in portions of game fish taken from Moira Lake, 1967.

Portion	Arsenic (ppm)	Number of samples
whole fish	0.28	8
muscle	0.06	7
gonad	0.28	2
liver	0.13	3
skin	0.22	7

Effect of Arsenic on Bottom Fauna

Table 5 illustrates the observed differences in bottom fauna communities above and below Deloro. A detailed

tabulation of these collections is appended. Station 8b was located immediately downstream of the discharge of treated surface runoff while station 8a was just upstream of this point but within the section of river where appreciable concentrations of arsenic, possibly from contaminated ground-water sources, have occurred in the past.

Table 5. Numbers of bottom fauna organisms collected at stations M6-M10 on the upper Moira River. The figure in brackets is the number of taxa identified within each at the major taxonomic groups.

Taxonomic Groups	M6	M7	M8a	M8b	M9	M10
Stonefly	1(1)	0	7(1)	6(1)	0	0
Mayfly	24(10)	54(13)	25(8)	5(4)	17(8)	11(3)
Caddisfly	23(10)	22(8)	85(11)	96(6)	30(5)	30(7)
Dragonfly	6(1)	1(1)	1(1)	3(1)	3(1)	0
Alderfly	1(1)	5(2)	3(1)	0	1(1)	0
Beetle and bug	23(1)	0	5(3)	0	1(1)	8(2)
Diptera	16(6)	3(1)	38(3)	1(1)	15(1)	20(1)
Crustaceans	1(1)	0	1(1)	0	0	0
Snails	0	92(3)	257(5)	3(1)	87(5)	196(4)
Clams	3(1)	48(1)	13(1)	0	1(1)	4(2)
Triclads	5(1)	5(1)	3(1)	0	2(1)	0
Worms	8(2)	1(1)	0	0	0	0
Total Organisms	111	231	438	114	157	279
Number of Taxa	35	31	36	14	24	19

Data summarized by the State Water Quality Board of California (1) reveal that concentrations of 3-14 ppm of arsenic have not been found harmful to mayflies and dragonfly nymphs survive concentrations of 10 - 20 ppm. Although concentrations of arsenic measured in the Moira River were less tha one ppm, the obvious reduction in the numbers and variety of organisms at station 8b and changes in the fauna at stations 9 and 10 suggested that concentrations during periods of low flow may be considerably higher or that there may be a long-term detrimental effect on the biotic community. This reduction is even more striking considering that the Moira River, from the upper reaches downstream through Deloro, flows from areas of Precambrian bedrock through areas of limestone bedrock and soils derived therefrom. Consequently, it should be expected that the variety and even abundance of organisms, particularly molluscs, would increase gradually downstream. (Hardness increasing from 88 to 144 downstream to Moira Lake). This tendency was apparent from station 6 downstream to Deloro but the pattern was disrupted at this point by the input of arsenic. The drastic reduction of molluscs with respect to the two upstream stations is noteworthy. While no taxum absent at station 8b other than triclads was consistently present at all upstream stations, the overall poorer fauna is significant. No adverse effect on bottom fauna communities was discernable at station 11 and further downstream.

Organic Wastes and Other Pollution Sources

Results are presented in the following sections dealing with the effects of domestic waste discharges from Madoc and Tweed and distillery wastes discharged at Corbyville

on water quality and bottom fauna communities in the respective portions of the river system. A tabulation of bottom fauna collections and results of chemical determinations are included in the Appendix.

Deer Creek

Sewage wastes from the village of Madoc enter Deer Creek immediately above station MD3 (Figure 2). At this point, the watercourse is narrow and characterized by alternate riffles and shallow pools. Further downstream it deepens and flows through an area of swampland before discharging to Moira Lake. Analyses of water samples revealed only a slight elevation of chemical parameters below the waste source, but excessive coliform densities persisted to station MD4. Although there was an adverse effect on biota in the riffles immediately below the discharge, observations made at station MD3b some 1000 feet further downstream indicated advanced recovery. Sewage fungus, which was abundant below the outfall, was not observed at the downstream station and populations of mayflies, caddisflies and other invertebrates, sensitive to suspended solids and low dissolved oxygen, were similar to those observed at control stations.

Moira Lake

Station MD4, at the mouth of Deer Creek, was sampled using an Ekman dredge. The change from a riffle to a deep-water environment at this station was reflected by a change in the bottom fauna community. Benthos at this site more closely resembled that of the lake and did not reflect adverse water quality conditions. Water samples collected at

station B (see Figure 3) located in a small bay of the western basin of Moira Lake near the mouth of Deer Creek, revealed elevated levels of BOD, total nitrogen, ammonia, total phosphorus, solids and hardness. The bay is well sheltered and very shallow, supporting abundant growths of submergent aquatic vegetation. However, this is an obviously localized effect as chemical parameters and total coliform counts at other stations in the western basin were normal and compared favourably with those of the eastern basin. The bottom fauna at station B, including amphipods, Hyalella azteca, and the dragonfly nymph, Ischnura, indicated no serious impairment of water quality.

A summary of bottom fauna collections and physical chemical data for selected stations on Moira Lake is presented in Table 6. All of the lake, except for the littoral shelf along the north shore, has a bottom of rich black silt which does not support a varied fauna. Decomposition of organic matter in these sediments would be expected to exert a high benthic oxygen demand resulting in a possible depletion of dissolved oxygen at the mud-water interface or in interstitial water. Thermal profiles and dissolved oxygen levels measured in August, 1967, revealed weak thermal stratification in deeper areas of Moira Lake and dissolved oxygen values as low as 0.0 ppm at station D and 0.6 ppm at station I. Bottom fauna obtained from predominantly organic sediments were restricted to only those organisms capable of withstanding low dissolved oxygen levels. Only tolerant midge larvae (Chironomidae) were found at station D and these dominated the communities at

Table 6. Physical-chemical characteristics and average number of organisms per square foot of bottom at selected stations on Moira Lake in August, 1967.

	A	B	C	D	E	F	G	H	I	J	K	L	5	8
Mayfly					.40						5.3	2.1	3.6	
Caddis											1.8	1.8		1.8
Dragonfly		1.8												3.6
Alderfly										1.8		7.8	1.8	3.6
Biting Midge	2.8		8.2		7.8	39	3.6	55	5.3			8.9		
Phantom Midge	3.2		6.4		17	1.8	10	5.3					3.6	
Red Midge	15	34	3.9	19	6.7	3.5	45	7.1	48	14	34	35	3.6	14
Amphipod		21								1.8				1.8
Snail		1.8	.7					1.8			1.8	4.6		16
Clam					6.7		12	12		3.6	5.3	3.9		1.8
Worms					1.1		8.9	5.3	1.8			.7		
Total Organisms	21	58	19	19	40	44	80	86	55	21	48	65	21	41
Number of Taxa	3	4	4	1	6	3	5	6	3	4	5	11	4	9
Sediment [1]	SiD	SiD	Si	Si	Si	Si	Si	Si	Si	SaD	Sa Si Sh	Si Sh	Sa Sh	Sa Sh
Depth	8'	4½'	19'	24'	19'	19'	25'	21	25'	12'	13'	7'	13	4'
Bottom DO (ppm)	7.0	4.0	7.0	0.0	5.0	6.0	6.0	6.0	3.0	4.0	6.0	6.0	-	-
Bottom Tem. (°C)	23	23	23	14	20	20	19	21	22	22	24	23	24	24

1 Si-silt, Sa-sand, Sh-shell. D-debris

other deep stations. Sand or sandy-silt substrate occurred at stations in the littoral region of the lake. Because of the different nature of the substrate and shallower depths, oxygen concentrations at these stations were sufficient to permit the survival of the more sensitive mayflies, caddisflies and alderflies.

Although arsenic levels in lake sediments were relatively high, it is doubtful that toxic effects were produced. The restriction of bottom fauna diversity at deeper stations in the lake would be expected solely on the basis of dissolved oxygen resulting from the accumulation and decomposition of organic material produced in the lake. Furthermore, bottom fauna communities of Moira Lake were typical of those generally found in other eutrophic lakes having similar oxygen profiles.

Results of other studies, which have dealt primarily with fish populations (2) and phytoplankton production (5), further substantiate the eutrophic state of Moira Lake. The lake supports a diversity of fish species, including game fish, and production rates are high. The latter can be largely attributed, either directly or indirectly, to high phytoplankton productivity. While this is beneficial from the point of view of fish production, excessive algal production leading to frequent blooms of particularly troublesome blue-green species in recent years, has seriously impaired aesthetic qualities and other recreational uses of the lake.

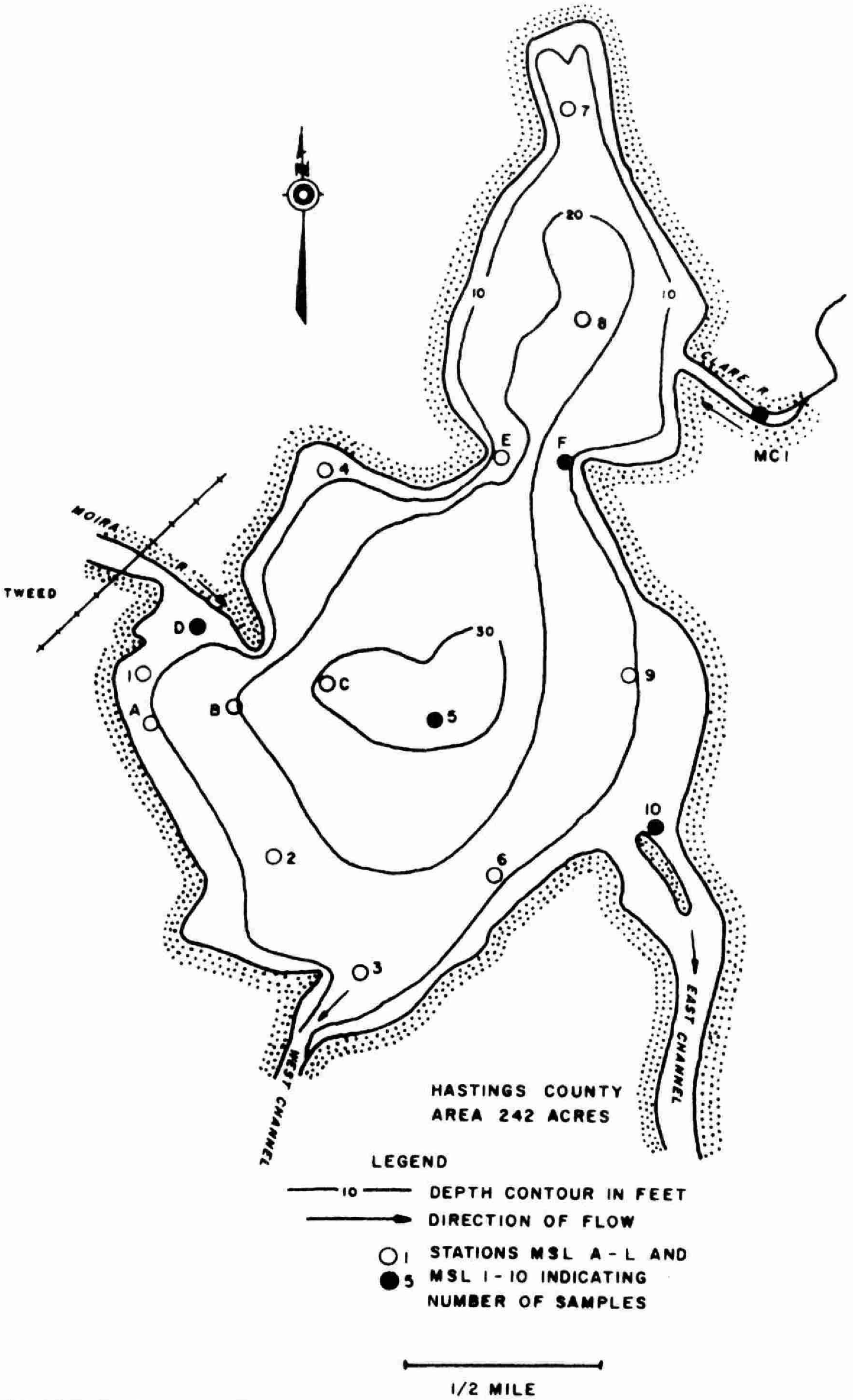
Stoco Lake

Stoco Lake (Figure 4) receives domestic wastes from Tweed. The lake is very similar to Moira Lake in physical, chemical and biological features and supports an excellent warm-water sport fishery. Excessive algal blooms have occurred frequently during summer months although these have not been of the same magnitude or severity as those of Moira Lake.

Chemical and biological parameters revealed no direct impairment of water quality attributable to waste discharges from Tweed. Chemical characteristics were generally uniform throughout the lake with values for pH hardness alkalinity, and dissolved solids being somewhat lower than for Moira Lake and free ammonia somewhat higher. Concentrations of plant nutrients, nitrogen and phosphorus, were typical of a eutrophic lake; mean concentrations of total phosphorus and total nitrogen were 0.28 ppm and 0.82 ppm, respectively. Total coliform counts exceeded the Commission's objective for surface waters at station M16 on the Moira River and at stations A, B, C and D on Stoco Lake in the vicinity of Tweed. Densities ranging from 3.300 to 11,000 organisms per 100 ml were attributed to unchlorinated domestic waste discharges at Tweed. This condition has resulted in the frequent closure of the public bathing beach at Tweed by local health authorities.

Bottom fauna communities at all stations in the littoral region of the lake consisted of a variety of organisms including forms sensitive to organic pollution and communities were in most cases similar in species composition

FIG. 4 STOCO LAKE



and abundance to those observed in Moira Lake. An average of 10 taxa was found at station D, which compared favourably to results obtained at other littoral stations. However the greater abundance of organisms at this site reflected organic enrichment from domestic waste discharges. In the deeper portion of the lake. bottom fauna were restricted to forms tolerant of low dissolved oxygen levels. A population comprised only of midge larvae (Chironomidae) was found at station C and midge larvae (Chironomidae. Heleinae. Chaoborus sp.), along with tubificid worms, occurred at station 5. Determinations of dissolved oxygen in July revealed concentrations of 0.2 ppm and 0.0 ppm in bottom water at stations 5 and C respectively. Depletion of dissolved oxygen, in this case, was undoubtedly related to a high benthic oxygen demand created by the decomposition of aquatic vegetation and reflects the extremely fertile and natural eutrophic condition of the lake.

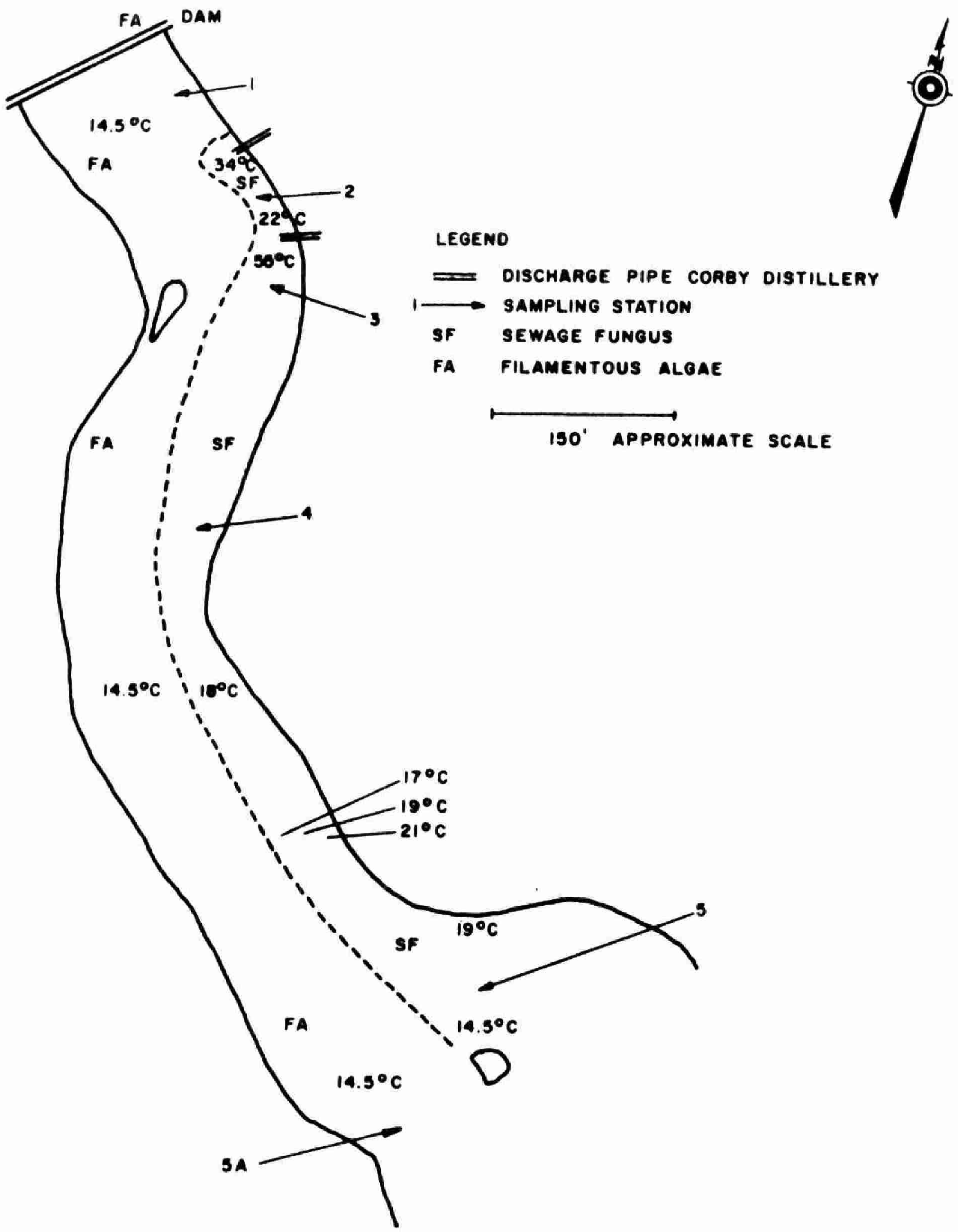
Corbyville

Owing to the distribution of sampling sites at and below Corbyville and abnormally high flows during the survey period of 1967, survey results were generally inconclusive. Consequently. this area was revisited in 1968 for a more detailed examination of pollutional effects on aquatic biota.

The control station, M23, was resampled and designated station 1. Also, a number of additional sampling sites were selected, the locations of which are shown in Figure 5. A final station, 6, which was located approximately a mile further downstream, is not shown on the figure.

FIG. 5 MOIRA RIVER AT CORBYVILLE

SHOWING LOCATIONS OF STATIONS, WATER TEMPERATURES, AND DISTRIBUTION OF SEWAGE FUNGUS AND FILAMENTOUS ALGAE



The distribution of sewage fungus versus that of filamentous algae and the areas of higher water temperatures delineate the path of the effluent (Figure 5). The fast current at this point prevents the complete mixing of waste water with the river. Consequently the effect of the effluent was restricted to the east shore for a considerable distance downstream.

Bottom fauna communities in the affected portion of the river were restricted in variety and total numbers (Table 7).

Table 7. Major groups of bottom fauna collected at seven stations on the Moira River at Corbyville, 1968.

Taxonomic groups	1	2	3	4	5	5A	6
Stonefly	0	0	0	0	0	2	0
Mayfly	29	0	0	1	1	14	1
Caddis	61	1	8	11	15	49	8
Other	40	26	14	22	30	32	34
Total number organisms	130	27	22	34	47	97	43
Number of Taxa	21	9	9	14	14	16	12

The presence of mayflies (Stenonema, Baetis, Ephemerella) and a wide variety of caddis larvae (10 genera) indicated water of excellent quality at station 1 above the discharge. Collections at stations 2 to 5 selected at increasing distances downstream of the outfalls along the east shore, showed a considerable degree of water quality impairment, although partial recovery was noted at station 5

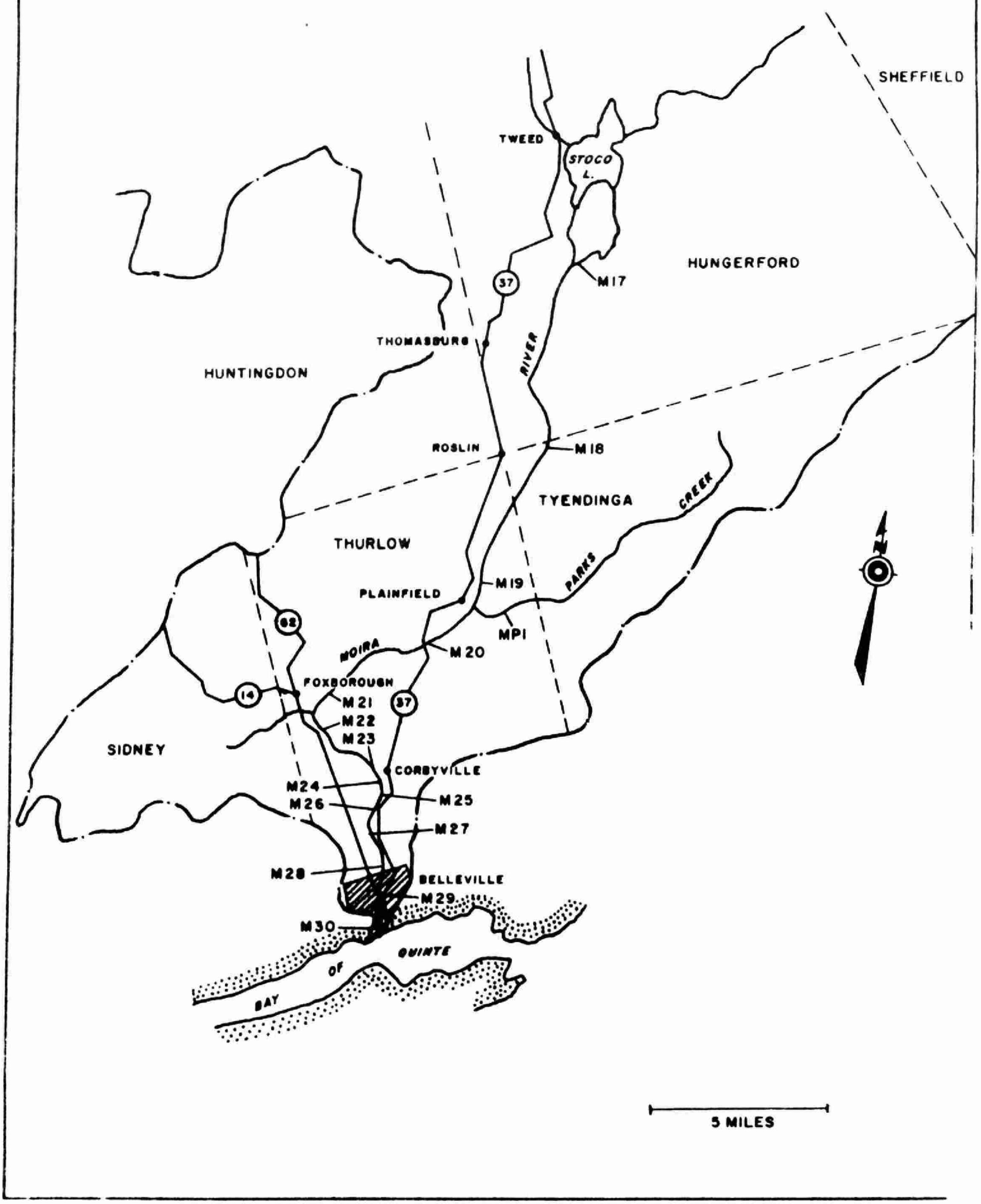
approximately 1200 feet below the lower discharge. Recovery at this point was further demonstrated by the fact that sewage fungus, which appeared immediately below the upper discharge and was extremely abundant at station 3, had become scarce and water temperatures were nearly back to normal. Complete mixing of waste-water with the river was not evident at this point. At station 5A, sewage fungus was not observed and water temperature was the same as at the control site. Also, the bottom fauna community at this station was not noticeably altered. Below station 5, the river is backed up by the dam at Cannifton. Station 6 was situated in this section of the river near the east shore, about a mile downstream of Corbyville. Due to the lack of riffle habitat at this site, it was not possible to make direct comparisons with results obtained at upstream stations. However, the bottom fauna community at this point was typical of an unpolluted, quiet-water habitat.

Growths of aquatic vegetation were extremely abundant throughout the impounded portion of the river between Corbyville and Cannifton in comparison with other sections of the river and suggested increased enrichment attributable to additions of plant nutrients in wastes discharged at Corbyville.

Other River Reaches

Other river reaches examined in the course of the survey included the remainder of the lower Moira River below Stoco Lake (Figure 6), the Black, Skootamata and Clare rivers draining the northern and eastern sections of

FIG. 6 LOWER MOIRA WATERSHED



the watershed and several smaller tributaries including Jordan, Eldorado and Park's creeks. All stations on these rivers supported a wide variety of pollution-sensitive fauna. The particularly rich fauna of caddisflies and mayflies was noteworthy.

The riffle habitat at station M29 in the city of Belleville supported a healthy biota and while it was difficult to assess the results obtained at M30 because of the hard bottom encountered while dredging, the bottom fauna organisms which were obtained indicated that the water entering the Bay of Quinte was probably of reasonable standards.

Impairment of water quality of Jordan Creek was noted below the village of Millbridge. At station MJ2, a coliform count in excess of three million organisms per 100 ml indicated contamination of the creek by sanitary wastes. However, while a slight decrease in diversity and increase in abundance of bottom fauna was observed at this station, the presence of a variety of intolerant species indicated only minor effects from organic pollution on invertebrate populations.

DISCUSSION

Arsenic Contamination

The results of surveys carried out since 1958 have clearly demonstrated a trend towards decreasing concentrations of arsenic in water samples collected from the Moira River below Deloro and from Moira Lake. Although

this trend may be partly the result of greater dilution afforded by gradually increasing streamflows since 1963, the reduction in arsenic contamination at Deloro is apparent. Nonetheless, concentrations downstream of Deloro are still consistently higher than background levels and are far in excess of the Commission's objective of 0.05 ppm.

While concentrations of arsenic in river sediments below Deloro have declined since 1958, levels in the sediments of Moira Lake and Stoco Lake have shown a significant increase. These findings illustrate the role of the lake environments in removing arsenic from the river system. The continuation of arsenic contamination can be expected to result in a further build-up in the already high levels noted. The significance of these accumulations cannot be stated for certain but the possibility must be recognized of re-contamination of lake water through return of arsenic into solution, resuspension of sediments or uptake and cycling by aquatic biota.

Concentrations of arsenic in water and game fish of Moira Lake - average of 0.16 ppm and 0.06 ppm, respectively - raise the question of their suitability for human consumption. It has been reported that ingestion of 130 mg of arsenic causes death in humans and 10 mg is sufficient to produce symptoms of acute toxicity (1). Arsenic excretion is slow and cumulative toxic effects may occur from frequent consumption of smaller dosages. The standard for drinking water of 0.05 ppm has generally been accepted, although maximum permissible concentrations as high

as 0.5 ppm have been recognized. Considering existing concentrations in Moira Lake, the possibility of acute toxic effects would seem remote. However, the implications of the seasonal use of Moira Lake for domestic supplies by cottagers and resort owners and the consumption of game fish should be assessed by health authorities.

Lake Enrichment

The highly eutrophic condition of Moira Lake and Stoco Lake is indicated by the depletion of dissolved oxygen and reduction in diversity of bottom fauna populations, together with the frequent occurrence of excessive blooms of blue-green algae. The enrichment and existing productivity levels of these lakes are undoubtedly related more to natural factors, including morphometric features and contributions of plant nutrients (nitrogen and phosphorus) in runoff from the watershed, than to added sources of nitrogen and phosphorus from domestic wastes.

Other work has shown that annual yields of 390 pounds of phosphorus and 1360 pounds of nitrogen per square mile may be expected in runoff from predominantly forested watersheds (9). On the basis of these figures, estimated annual yields of phosphorus and nitrogen to Moira Lake are 83,800 pounds and 293,000 pounds respectively. In comparison, calculations on the basis of 6.1 pounds of phosphorus per capita per year and an assumed waste volume of 70 gal. per capita per day containing 20 ppm total nitrogen, provide estimated annual yields from Madoc domestic wastes of 3,500 pounds of phosphorus and 8,700 pounds of

nitrogen or 3.6 and 2.6 per cent, respectively, of annual yields in runoff from the watershed. A similar comparison can be drawn with respect to domestic waste discharges to Stoco Lake.

Consequently, while artificial enrichment has undoubtedly contributed somewhat to lake eutrophication, the elimination of these sources cannot be expected to significantly reduce existing levels of primary productivity.

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APPENDIX A

Collections of benthic macro-invertebrates from Moira River, Moira Lake, Stoco Lake, and major tributaries, 1967. Collecting methods are outlined in the text of the report. Specimens have been placed in the permanent collections of the Biology Branch as items 67B649 to 67B778 and 68B745 to 68B751.

Table 1	Upper Moira River
Table 2	Lower Moira River
Table 3	Black River and Skootamatta River
Table 4	Deer Creek
Table 5	Jordan River, Eldorado Creek, Park's Creek and Clare River
Table 6	Moira River at Corbyville, 1968
Table 7	Moira Lake
Table 8	Stoco Lake

Table 1. Upper Moira River - M1 to M12

Taxa	M1	M2	M3	M5	M6	M7	M8a	M8b	M9	M10	M11	M12
STONEFLIES												
Neophasganophora sp.		2										
Acroneuria sp.			1	4	1		7	6				
Perlesta placida	1											1
MAYFLIES												
Ephemera simulans			2									
Choroterpes sp.			2		2	8	1			3		
Stenonema femoratum			6			4						
Stenonema ares		1					2					
Stenonema tripunctatum											2	1
Stenonema fuscum	1	6	1		1	1		1	3			
Stenonema candidum						1						
Stenonema gildersleevei	11	22	28						3			
Stenonema heterotarsale	1											
Stenonema sp.	1		3	3	4	2	1	2	1			
Heptagenia maculipennis			1		5							
Heptagenia pulla			1									
Heptagenia aphrodite					2		7					
Heptagenia sp.						1						2
Caenis sp.				1				1	2	7	6	28
Tricorythodes sp.		1			1	4	1					
Isonychia sp.	2								1			
Baetis herodes									3			
Baetis frondalis	3	3		1		1						
Baetis intercalaris							3		3			
Baetis vagans					4	1						
Baetis levitans						1						
Baetis sp.	3					25						
Centroptilum sp.		1		2	1	3						
Pseudodoeon sp.	1				1		4	1		1	1	4
Cloeon sp.	2											
Ephemerella sp.				2	3	2	6		1			
CADDISFLIES												
Cheumatopsyche sp.	20	10	20	12	1	3	9	3	4			
Hydropsyche betteni	55	5		21			2	1				
Hydropsyche bifida		1		27	3	1	20	17	13	12	2	1
Hydropsyche sp.	8	1	1	17	6		38	73	11	10	3	
Macronemum zebratum				1								20
Hydropsychidae (pupa)				1			2			2		
Polycentropus sp.		2				1		1		1		1
Neureclipsis sp.						4	3	1				
Psychomyia sp.			2		3				1			
Cyrnellus sp.		1	2		1				1		1	

continued

Table 1 - continued - Stations M1 to M12

Taxa	M1	M2	M3	M5	M6	M7	M8a	M8b	M9	M10	M11	M12
CADDISFLIES - cont'd												
Chimarra obscura		3		20	3					1		
Chimarra feria					2							
Chimarra socia						1						
Hydroptila sp.											1	
Rhyacophila fuscula					1							
Oecetis cinerascens												1
Oecetis inconspicua							2				1	
Oecetis sp.				2			1			1		
Triaenodes injusta							1				7	
Triaenodes sp.										1		2
Mystacides sepulchralis						8	4			2	1	
Micrasema (pupa)							1					
Pycnopsyche guttifer		5	9		2	2						
Neophylax oligius			5	6	1		2					
Helicopsyche sp.			27			2						
Malanna sp.			1									
MEGALOPTERA												
Corydalus cornutus					1	4						
Chauliodes sp.		2							1			
Sialis sp.		1				1	3					
DRAGONFLIES												
Aeshna sp.			2			1						
Argia sp.		2			6			3	3		1	
Ischnura sp.							1				2	3
unidentified												1
BEETLES												
Tropisternus sp.												3
Dubiraphia sp.				1								
Elsianus sp.		1										
Ectoparia sp.		1		1								
Psephenus sp.		8	9	3	22							
adults			1	2	1		3				4	2
HEMIPTERA												
Rhagovelia sp.							1			3		
Rheumatobates sp.									1			
Mesoveliidae							1			1		

continued

Table 1 - continued - Stations M1 to M12

Taxa	M1	M2	M3	M5	M6	M7	M8a	M8b	M9	M10	M11	M12
DIPTERA												
<u>Antocha</u> sp.				1	5							
<u>Tipula</u> sp.					1							
<u>Paradelphomyia</u> sp.					3							
<u>Chrysops</u> sp.					1							
<u>Simulium</u> sp.	88	9		5								
Heleinae							1					3
Chironomidae	11	10	17	19	5	3	36	1	15	20	31	9
Empididae				1								
<u>Hemerodromia</u> (pupae)					1		1				1	2
CRUSTACEANS												
<u>Orconectes</u> <u>virilis</u>					1							
<u>Hyalella</u> <u>azteca</u>	1		1				1				29	
MOLLUSCS												
<u>Physa</u> sp.			4			78	203	3	73	148	132	26
<u>Lymnaea</u> sp.						1	19		2	8	13	8
<u>Helisoma</u> sp.									1		2	3
<u>Gyraulus</u> sp.							1				39	5
<u>Valvata</u> <u>tricarinata</u>							27		1	28	7	
<u>Amnicola</u> sp.						13	7		10	12	23	29
<u>Sphaerium</u> sp.			6	3	3	48			1	1	3	
<u>Pisidium</u> sp.			2				13			3		
<u>Elliptio</u> <u>complanatus</u>												
LEECHES												
<u>Helobdella</u> sp.											2	
<u>Placobdella</u> <u>ornata</u>											1	
TRICLAD												
<u>Cura</u> <u>foremanii</u>	2	5	2	1	5	5	3		2		21	2
OLIGOCHAETA												
Tubificidae					7	1						2
Lumbriculidae					1							1

Table 1 - continued - Stations M14 to M16

Taxa	M14	M15	M16
STONEFLY			
Acroneuria sp.		9	6
MAYFLIES			
Choroterpes sp.		2	2
Stenonema tripunctatum	24		
Stenonema gildersleevei		1	
Stenonema sp.		7	1
Heptagenia maculipennis		10	
Caenis sp.	3	1	1
Tricorythodes sp.			1
Isonychia sp.			1
Baetis intercalaris		17	
Baetis pygmaeus		1	
Baetis sp.		1	
Centroptilum sp.		3	
Pseudocloeon sp.		7	
Ephemerella sp.		4	
CADDISFLIES			
Cheumatopsyche sp.	3	5	
Hydropsyche betteni	3		
Hydropsyche bifida group		20	22
Hydropsyche sp.	2	9	3
Macronemum zebratum		3	
Neureclipsis sp.			1
Chimarra obscura		7	
Rhyacophila sp.		1	1
Athripsodes flavus	1		
Athripsodes tarsi-punctatus		1	
Mystacides sepulchralis		1	1
Micrasema sp.		1	
Pycnopsyche guttifer		1	
Helicopsyche sp.		5	
MEGALOPTERA			
Corydalus cornutus		1	
DRAGONFLIES			
Ischnura sp.	3		
LEPIDOPTERA			
unidentified			1

continued

Table 1 - continued - Stations M14 to M16

Taxa	M14	M15	M16
BEETLES			
Berosus sp.	1		
Tropisternus sp.	1		
Paracymus sp.	2		
Psephenus sp.		6	4
adults	3	5	
HEMIPTERA			
Belostomatidae	1		
DIPTERA			
Tipula sp.	1		
Simulium sp.	1000+	7	
Heleinae			1
Chironomidae		2	4
CRUSTACEAN			
Hyalella azteca	2		
MOLLUSCS			
Physa sp.	8	4	
Helisoma sp.	2		
Gyraulus sp.	3		
Sphaerium sp.		34	
LEECHES			
Helobdella sp.	1		
Erpobdella punctata			1
TRICLAD			
Cura foremanii	17		1
OLIGOCHAETA			
Tubificidae			5

Table 2. Lower Moira River - Stations M17 to M30.

Taxa	M17	M18	M19	M21	M22	M23	M24	M25	M27	M28	M29	M30
STONEFLY												
Acroneuria sp.		8	11	1			1	1	1	2		
MAYFLY												
Choroterpes sp.		1										
Stenonema tripunctatum	1											
Stenonema gildersleevei		3								5	9	
Stenonema sp.		8	8			4		5	11	11	23	
Heptagenia maculipennis									1		1	
Caenis sp.		4			1							
Tricorythodes sp.											1	
Isonychia sp.		1										
Baetis herodes									2	1	1	
Baetis sp.		2	1									
Centroptilum sp.		2	2			1	3	3	5			
Pseudocloeon sp.			1				2	1	15	11	6	
Ephemerella		2	2					10	6	9	68	
CADDIS												
Cheumatopsyche sp.	53	28	9	6		10	3	7	61	4	8	
Hydropsyche betteni		3										
Hydropsyche bifida group	258	38	26	1		1	3	26	77	24	64	
Hydropsyche sp.	32	57	66	66		54	107	118	152	14	39	
Macronemum zebratum			5									
Hydropsychidae (pupa)	12	2				2				2	1	
Hydroptila sp.									19		2	
Neureclipsis sp.	22								1			
Psychomyia sp.			3									
Cyrnellus sp.			1	1								
Chimarra obscura		4		1		36	3		24	2	6	
Chimarra socia		2										
Rhyacophila fuscula	1											
Rhyacophila sp.		1					2					
Oecetis sp.	1	5							11	1		
Athripsodes flavus									2			
Athripsodes tarsi-punctatus										1		
Athripsodes sp.						1						
Triaenodes injusta		1		1								
Mystacides sepulchralis		1										
Pycnopsyche guttifer		1										
Psilotreta sp.						1						
Marilia sp.		1	1									
Helicopsyche sp.	2	13						1				
Brachycentrus numerosus		10	27			2		2	6			

continued

Table 2. continued - Stations M17 to M30

Taxa	M17	M18	M19	M21	M22	M23	M24	M25	M27	M28	M29	M30
MEGALOPTERA												
Corydalus cornutus				2								
Chauliodes sp.			1									
Sialis sp.					1							
DRAGONFLY												
Ischnura sp.					2			1				
LEPIDOPTERA												
Elophila sp.			1	4				1	1	1		
Unidentified												
BEETLE												
Tropisternus sp.										2		
Peltodytes sp.		3								2		
Elsianus sp.							1		2			
Neoelmis sp.	1			1								
Ectoparia sp.	4	1										
Psephenus sp.	6	19	5				2				5	
adults	6	1									1	
HEMIPTERA												
Rhagovelia sp.		4								1		
Belostomatidae								1				
DIPTERA												
Antocha sp.								1				
Simulium sp.	1	16		8		3			11	1	5	
Heleinae	1											
Chironomidae	9	15	3		4	1	4	4	43	45	29	3
CRUSTACEAN												
Orconectes sp.		1										
Hyalella azteca	72	15		9	19	2		1	38	88	6	
Asellus sp.		1		1	2				19		2	14
MOLLUSCS												
Physa sp.	36	15		1		1	11		3	28	10	2
Lymnaea sp.	8								1			
Helisoma sp.								1	4			
Gyraulus sp.			1									2
Valvata tricarinata					1							
Amnicola sp.	2				2							
Sphaerium sp.	15	5	17	20		15	49		3			
Pisidium sp.												1
Elliptio complanatus				1		3						
Ligumia nasuta						1						

continued

Table 2. continued - Stations M17 to M30

Taxa	M17	M18	M19	M21	M22	M23	M24	M25	M27	M28	M29	M30
LEECHES												
Helobdella stagnalis									8			1
Helobdella sp.				1				40				
Glossiphonia complanata		3						1	2	1		
Placobdella ornata			1									
Erpobdella punctata								3	4			
Unidentified	1											
TRICLAD												
Cura foremanii	6	23							58	106	15	23
OLIGOCHAETA												
Tubificidae	1											7

Table 3. Black and Skootamatta Rivers - Stations MB1 to MS4.

Taxa	MB1	MB2	MB3	MB4	MS1	MS2	MS3	MS3[1]	MS4[1]
STONEFLIES									
Acroneuria sp.	3	2	13	8	2		1		
Neoperla sp.			1						
MAYFLIES									
Ephemera sp.								4	
Hexagenia sp.									13
Iron sp				4		2			
Cinygma sp.						1			
Stenonema fuscum	2	4		1					
Stenonema gildersleevei	3				1				
Stenonema pudicum	20								
Stenonema sp.	7	1	8	11	8	6	1	1	
Heptagenia maculipennis				5		2			
Heptagenia hebe					1				
Heptagenia sp.							1		
Caenis sp.								1	
Tricorythodes sp.		2		3		1			
Isonychia sp.			2	1					
Baetis frondalis							3		
Baetis herodes			1						
Baetis intercalaris	5		1	14					
Baetis pygmaeus	1						2		
Baetis sp.					5				
Centroptilum sp.		1	4	10	1	4			
Pseudocloeon sp.	2	6		8		1			
Choroterpes sp.	1	1							
Paraleptophlebia mollis						2			
Paraleptophlebia sp.	2		14	29					
Ephemerella sp.					2	3	2		
CADDISFLIES									
Cheumatopsyche sp.	2	7	11	41	1		4		
Hydropsyche betteni	5	1	1	4	73	16			
Hydropsyche bifida group		6	3	6					
Hydropsyche sp.	35	12	92	152			10		
Macronemum zebratum		20	4	1		13	10	1	
Hydropsychidae (pupae)					3	1	1		
Neureclipsis sp.		1	1	2		2			
Phylocentropus sp.	4	1	1					1	2
Cyrnellus sp.		1	1		4				
Lype sp.							3		
Chimarra aterrima					1	3	2		
Chimarra obscura		21	4	7	3	4	37		
Chimarra socia				1	2	1			
Chimarra sp. (pupae)					1	1			
Hydroptila sp.					2				

continued

Table 3. continued - Stations MB1 to MS4

Taxa	MB1	MB2	MB3	MB4	MS1	MS2	MS3	MS3[1]	MS4[1]
CADDISFLIES - con'td									
Rhyacophila fuscula					2				
Oecetis cinerascens								1	
Oecetis sp.					1				
Mystacides sepulchralis		3							
Pycnopsyche guttifer	4	4							
Pycnopsyche lepida						1		2	
Molanna sp.	4	1						5	2
Neophylax oligius		3							
Glossosoma sp.					1				
MEGALOPTERA									
Corydalus cornutus					1				
Chauliodes sp.		1	2	1	2				
Sialis sp.					1			3	14
DRAGONFLIES									
Ischnura sp.								1	1
Argia sp.						2			1
Agrion sp.	2							1	
Macromia sp.								3	
Gomphus sp.			1						
Gomphoides sp.		1							
Dromogomphus sp.							1	2	1
Boyeria sp.							1		
Didymops sp.			1				1		
BEETLES									
Psephenus sp.	3	2						1	
Ectoparia sp.				1					
Macronychus sp.	1						1		
Elsianus sp.		2							
Ordobrevia sp.					3				
Gyrinus sp.								1	
Donacia sp.								2	
adults	1			3	1				
HEMIPTERA									
Rhagovelia sp.						3	1		
unidentified						2			
DIPTERA									
Antocha sp.	1				5		1		
Tipula sp.		3			1				
Chrysops sp.									3

continued

Table 3. continued - Stations MB1 to MS4

Taxa	MB1	MB2	MB3	MB4	MS1	MS2	MS3	MS3[1]	MS4[1]
DIPTERA - continued									
Simulium sp.	1	10		279	5	4	10		
Heleinae									1
Chironomidae	30	7			29	9	24	9	57
Hemerodromia sp.						1			
CRUSTACEANS									
Orconectes rusticus					1				
Orconectes sp.	2					3	1	1	
Hyalella azteca	4	1					7		
Crangonyx sp.						2			
Asellus sp.	5	28							
MOLLUSCS									
Physa sp.	1	5							
Campeloma sp.		2	21	42				1	5
Sphaerium sp.							4	12	1
Elliptio complanatus		1				2			10
LEECHES									
Helobdella stagnalis		1							
Helobdella sp.	3	1							
Glossiphonia complanata		1							
Erpobdella punctata		1							
TRICLAD									
Cura foremanii						1	1		
OLIGOCHAETA									
Tubificidae						1	2	2	
Lumbriculidae								1	

1 5-6x6 inch Ekman dredges composited.

Table 4. Deer Creek - Stations MD1 to MD4

Taxa	MD1	MD2	MD3	MD3[1]	MD4 a	b	c	d	e
MAYFLIES									
Choroterpes sp.		3							
Stenonema fuscum	1								
Stenonema femoratum	1								
Stenonema vicarium		3							
Stenonema gildersleevei		1							
Stenonema sp.	1								
Heptagenia sp.	5								
Tricorythodes	3		1						
Baetis intercalaris	31								
Baetis pygmaeus		10							
CADDISFLIES									
Cheumatopsyche sp.	77	153	53						
Hydropsyche bifida group	121	2	1						
Hydropsyche betteni	131	47	20						
Hydropsyche slossonae	6								
Hydropsyche sp.	133	10	4						
Hydropsychidae (pupa)	1		2						
Psychomyia sp.	3								
Chirmarra aterrima	3								
Hydroptila sp.	1								
Oecetis inconspicua			1						
Triaenodes sp.		2							
Pychopsyche guttifer	1		1						
Micrasema sp.	1								
DRAGONFLIES									
Agrion sp.	1								
BEETLES									
Haliplus sp.				1					
Optioservus sp.	2	17							
Psephenus sp.	7	5							
adults	3								
HEMIPTERA									
Corixidae			2						
Mesoveliidae				1					
DIPTERA									
Antocha sp.	42		2						
Chrysops sp.	5			2					
Simulium sp.	3	3	20						
Dixa sp.	1								
Heleinae					2	58	2	1	
Chaborus sp.							5		
Chironomidae	67	34	329	80	50	1	24	54	64
Hemerodromia (pupa)		1							

continued

Table 4. continued - Stations MD1 to MD4

Taxa	MD1	MD2	MD3	MD3[1]	MD4				
					a	b	c	d	e
CRUSTACEANS									
<u>Orconectes</u> <u>rusticus</u>		1							
<u>Orconectes</u> sp.	1	1							
<u>Hyalella</u> <u>azteca</u>	2	39	8						28
MOLLUSCS									
<u>Physa</u> sp.	14	117	103	1					
<u>Lymnaea</u> sp.	2		3						
<u>Valvata</u> <u>tricarinata</u>			3	5					
<u>Amnicola</u> sp.		1							
<u>Sphaerium</u> sp.	12	1	1						
<u>Pisidium</u> sp.	1	1	1						
LEECHES									
<u>Helobdella</u> sp.	1								
<u>Glossiphonia</u> <u>complanata</u>				1					
<u>Erpobdella</u> <u>punctata</u>		3	1	1					
TRICLAD									
<u>Cura</u> <u>foremanii</u>		1							
OLIGOCHAETA									
Tubificidae				22			2	1	1

1 5-6x6 inch Edman dredges composited.

Table 5. Jordan River, Eldorado Creek, Park's Creek, Clare River Stations MJ1 to MC1

Taxa	MJ1	MJ2	ME1	MP1	MC1 a	b	c	d	e
STONEFLY									
Acroneuria sp.				1					
MAYFLIES									
Hexagenia sp.								4	1
Choroterpes sp.	1								
Stenonema gildesleevei	9								
Stenonema tripunctatum	2	1							
Stenonema vicarium	3	21							
Heptagenia pulla		1							
Baetis frondalis	6	10							
Caenis sp.			1	1					
Centroptilum sp.				3					
CADDISFLIES									
Cheumatopsyche sp.	75	39		16					
Hydropsyche betteni	8	187							
Hydropsyche bifida group	1			36					
Hydropsyche sp.	1	20		32					
Hydropsychidae (pupae)	3			1					
Phylocentropus sp.						2			1
Polycentropus sp.					1				2
Cyrnellus sp.		1							
Chimarra obscura				2					
Chimarra socia				1					
Rhyacophilia fuscula				6					
Rhyacophilia sp.				3					
Oecetis (pupa)				1					
Pycnopsyche guttifer	5								
Pycnopsyche lepida				1					
Neophylax sp.				3					
Brachycentrus numerosus				229					
Molanna sp.								1	
Glossosoma (pupa)	2								
Helicopsyche sp.				3					
MEGALOPTERA									
Chauliodes sp.				2					
Sialis sp.			1						1

continued

Table 5. continued - Stations MJ1 to MC1

Taxa	MJ1	MJ2	ME1	MP1	MC1 a	MC1 b	MC1 c	MC1 d	MC1 e
DRAGONFLIES									
Ischnura sp.						1			
Dromogomphus sp.							1		
Macromia sp.									
LEPIDOPTERA									
Nymphula sp.						2			
Elophila sp.				6					
BEETLES									
Gyrinidae				6					
Optioservus sp.	1	1							
Elsiamus sp.	2								
Dubiraphia sp.									1
Ordobrevia sp.				4					
Psephenus sp.				1					
adults		1							
HEMIPTERA									
Corixidae				1					
Gerris sp.				2					
DIPTERA									
Antocha sp.	1			1					
Dicranota sp.									
Simulium sp.	5	4		1					
Heleinae	1				1			1	
Chironomidae	43	23	210	9	6	6	14	14	12
Chrysops sp.					1				
CRUSTACEANS									
Orconectes sp.	4			2					
Hyalella azteca			1	1	6	2	9	4	15
MOLLUSCS									
Physa sp.			2	18				1	1
Amnicola sp.					30	8	33	4	18
Sphaerium sp.			2	18	3		3	3	2
Pisidium sp.			3			1	2		
LEECHES									
Helobdella sp.						1		1	
Helobdella stagnalis			1						
Placobdella ornata		1							

continued

Table 5. continued - Stations MJ1 to MC1

Taxa	MJ1	MJ2	ME1	MP1	MC1 a	b	c	d	e
TRICLAD									
Cura foremanii								1	
OLIGOCHAETA									
Tubificidae		2	1		4	1		2	3

Table 6. Moira River - Corbyville (1968) Stations 1 to 6

Taxa	1	2	3	4	5	5A	6
STONEFLY							
Togoperla sp.						2	
MAYFLIES							
Stenonema sp.	16			1	1	11	1
Baetis sp.	11					2	
Centroptilum sp.						1	
Ephemerella sp.	2						
CADDISFLIES							
Cheumatopsyche sp.	16	1			2	9	
Hydropsyche sp.	16		8	9	11	14	
Macronemum zebratum	3			1		1	
Polycentropus sp.	1						
Chimarra sp.	11					7	
Oecetis sp.	2						1
Athripsodes sp.	3					5	
Brachycentrus numerosus	6					6	
Helicopsyche sp.	2			1	1	7	
Agraylea sp.	1						7
Leptoceridae (pupa)					1		
DRAGONFLIES							
Agrion sp.		1					
BEETLES							
Ordobrevia sp.	5			1			
Elsianus sp.	4						
adults							2
DIPTERA							
Chironomidae		2	1	3	2	3	
CRUSTACEANS							
Hyalella azteca	13	2	1	1	12	20	4
Asellus sp.	5		3	2	1		7
MOLLUSCS							
Physa sp.	1	11	3	6	5	4	
Lymnaea sp.							3
Helisoma sp.				3	3	2	2
Gyraulus sp.	6	1					7
Amnicola sp.	4						4
Sphaerium sp.						3	

continued

Table 6. continued - Stations 1 to 6

Taxa	1	2	3	4	5	5A	6
LEECHES							
Helobdella stagnalis			1	1	1		3
Helobdella sp.				1			
Glossiphonia complanata				2	2		
Erpobdella punctata		3	2	2	1		2
TRICLADS							
Cura foremanii	2	1	1		3		
OLIGOCHAETA							
unidentified		5	2				

Table 7. Moira Lake - Western Basin - including M13

Taxa	A					B	C					D	1	2	3	M13				
	a	b	c	d	e		a	b	c	d	e					a	b	c	d	e
DRAGONFLY																				
Ischnura sp.						1														
DIPTERA																				
Heleinae	1	3	3	1			10	1	5	5	2		2	5	4	1		8		7
Chaoborus sp.		2	5		2			4	2	6	6		4	24	6			1		1
Chironomidae	9	6	12	10	6	19	2	2	1	4	2	11	9	3	10					
CRUSTACEAN																				
Hyalella azteca						12								1						
MOLLUSCS																				
Physa sp.						1														
Pisidium sp.								1			1									

Table 7. - continued - Eastern Basin

Taxa	E					F	G	H	M	I	J	K	L					5	6	7	8	9	10
	a	b	c	d	e								a	b	c	d	e						
MAYFLIES																							
Hexagenia sp.			1									3		1	1	3	1	2					
CADDISFLIES																							
Polycentropus sp.																					1		
Oecetis cinerascens												1			1	2	1						
Mystacides sepulchralis																	1						
MEGALOPTERA																							
Sialis sp.											1		9	2	2	7	2	1		2	2		
DRAGONFLY																							
Didymops sp.																					1		
Ischnura sp.																					1		
DIPTERA																							
Heleinae	7	6	2	1	6	22	2	14	31	3				8	7	3	7			3		7	4
Chaoborus sp.	8	14	7	5	12	1	6		3									2	6	2			3
Chironomidae	1	3	8	2	4	2	25	1	4	27	8	19	16	5	27	33	17	7	13	21	8	9	15
CRUSTACEAN																							
Hyalella azteca											1										1		
MOLLUSCS																							
Physa sp.									1														
Helisoma sp.													2				2						
Valvata tricarinata													1	1	3	3	1				1		
Amnicola sp.												1									8		
Sphaerium sp.														1									
Pisidium sp.			8	4	6		7	7			2	3	3	2		3	3				1		
OLIGOCHAETA																							
Tubificidae		1	1	1			5	3	1					2					1	4		1	1

Table 8. Stoco Lake - A to F.

Taxa	A	B	C	D					E	F				
				a	b	c	d	e		a	b	c	d	e
MAYFLIES														
Choroterpes sp.				5	2		1							
Tricorythodes sp.				2				1						
Hexagenia sp.	4	6							13	14	36	21	15	11
CADDISFLIES														
Polycentropus sp.				1										
Phylocentropus sp.				41	10	33	49	18						
Neureclipsis sp.				2										
Oecetis sp.				2										
Mystacides sepulchralis				1										
Molanna sp.				1										
MEGALOPTERA														
Sialis sp.	3			1					1	9	12	10	10	4
Heleinae				1	1						1			
Chaoborus sp.				1					1	3		1		1
Chironomidae		1	11	17	29	35	10	22	5	13	6	9	5	9
CRUSTACEANS														
Hyalella azteca				50	3	6	3	1				1		
Asellus sp.				227	26	9	29	19						
MOLLUSCS														
Helisoma sp.									1					
Valvata sincera	1													
Amnicola sp.	1													
Pisidium sp.	1			1	1				2	2	2	5	3	2
Sphaerium sp.				1			1		2					
Elliptio complanatus	1			1	3		6		1			1		
Lampsilis siliquoidea							1							
Anodonta grandis														
LEECHES														
Helobdella stagnalis				2	2		2	1		1				
Erpopdellidae								1						
MITE														
unidentified				2							1			
OLIGOCHAETA														
Tubificidae	1			2	3	1	3							

Table 8 - continued - Stations 1 to 10.

Taxa	1	2	3	4	5					6	7	8	9	10				
					a	b	c	d	e					a	b	c	d	e
MAYFLIES																		
<u>Choroterpes</u> sp.																	2	
<u>Stenonema</u> <u>femoratum</u>																	1	
<u>Hexagenia</u> sp.	4	11	23	10						4	1		6	6	3	1		1
CADDISFLIES																		
<u>Polycentropus</u> sp.										1								
<u>M</u>. <u>sepulchralis</u>															2		1	
<u>Leptocella</u> sp.																		1
MEGALOPTERA																		
<u>Sialis</u> sp.	1	4	2								4		1	1				
<u>Didymops</u>																	1	
DIPTERA																		
Heleinae									1		1	2						1
<u>Chaoborus</u> sp.					30	25	51	31	66	4	10	18						
Chironomidae	12	1		6	4	5	5	1	3	3	18	2	1	14	11	12	7	8
CRUSTACEANS																		
<u>Hyalella</u> <u>azteca</u>				1						1				3	5	7	16	1
<u>Asellus</u> sp.				1											1			
MOLLUSCS																		
<u>Physa</u> sp.																	1	
<u>Valvata</u> <u>sincera</u>											2							
<u>Valvata</u> <u>tricarinata</u>	2										2							
<u>Amnicola</u> sp.		1									1							
<u>Pisidium</u> sp.	2	1	3						1		7	3				1		1
<u>Sphaerium</u> sp.										1		1		7	3	1	3	1
<u>Elliptio</u> <u>complanatus</u>	1			2						1	2			7	3	3	7	1
<u>Lampsilis</u> <u>siliquoidea</u>														1				
<u>Anodonta</u> <u>grandis</u>	1									1								
LEECHES																		
<u>G</u>. <u>complanata</u>																	1	
<u>Placobdella</u> <u>montifeva</u>																		1
OLIGOCHAETA																		
Tubificidae					1		5	2	4		1	30	1				1	3

Table 1. Moira River

Station	BOD_5	SOLIDS Susp.	Diss.	Total Phosphorus as PO_4	Total Kjeldahl Nitrogen	pH	Hardness as $CaCO_3$	Alkalinity as $CaCO_3$	Total Coliforms per 100 ml.
M1	1.5	4	80	0.48	0.71	7.7	88	71	
M2	1.2	5	145	0.45	0.71	8.1	88	78	840
M3	0.5	3	129			8.1	96	88	
M5	1.1	3	155		0.71	8.0	120	108	
M6	0.4	3	151		0.98	8.2	124	107	156
M7	0.6	3	145		0.78	8.1	120	109	
M8b	0.6	2	94		0.98	8.3	128	110	60
M9	1.3	5	163		0.71	8.3	128	112	204
M10	0.9	4	168		0.84	8.4	124	111	
M11	1.0	3	185			8.0	136	126	
M12	0.9	2	190			8.1	144	125	
M13	1.8	7	193		0.58	7.9	144	131	
M14	1.2	4	172			8.1	132	219	
M15	1.1	7	91	0.42	0.71	8.1	56	40	3200
M16	1.1	3	79	0.56	0.71	8.2	56	43	6300
M17	0.8	3	115	1.10	0.71	8.2	76	73	
M18	1.4	3	117	1.00	0.71	8.6	84	73	
M19	1.0	5	109			8.6	92	78	
M20	0.8	5	149	0.26	0.71	8.0	100	83	408
M21	0.7	2	116	0.36	0.71	8.0	96	85	292
M22	0.8	2	136		0.65	8.0	96		96
M23	0.6	4	124		0.65	8.1	104		276
M24	3.6	3	135	0.20	0.71	8.2	284	259	390
M25	3.0				0.71	7.9	100		540
M27	0.7				0.58	8.1	96		670
M28	0.7				0.71	8.2	100		
M29	0.9				0.65	8.3	104		
M30	0.9				0.98	8.5	104		

Table 2. Tributaries

Station	BOD_5	SOLIDS Susp.	SOLIDS Diss.	Total Phosphorus as PO_4	Total Kjeldahl Nitrogen	pH	Hardness as $CaCO_3$	Alkalinity as $CaCO_3$	Total Coliforms per 100 ml
MJ1	1.6	5	133	0.44	0.71	7.7	104	93	
MJ2	0.4	5	143			7.9	52	96	3,800,000
ME1	0.5	8	338	0.20	0.71	8.2	284	259	
MD1	0.5	8	338	0.20	0.71	8.2	284	259	1,020
MD2	0.2	3	267		0.71	8.1	244	216	270
MD3	1.9	3	293	0.18	0.58	7.9	248	228	120,000
MD4	1.4	8	348		0.98	7.8	280	267	6,000
MB2	0.4	3	63	0.44	0.65	7.7	36	26	
MB3	0.4	4	82	0.40	0.52	7.7	38	30	
MB4	0.4	3	61		0.58	7.6	40	30	
MS1	0.7	2	48			7.6	26	14	
MS2	0.7	4	34	0.55	0.65	7.5	26	16	
MS3	0.2	3	91	0.39	0.65	7.6	30	21	4,500
MS4	0.5	4	50		0.65	7.6	34		388
MC1	0.7	7	181	0.25	0.52	7.9	148	13	100
MP1	1.3	3	237	0.51	0.58	8.6	168	190	

Table 3. Moira Lake

Sta.	BOD_5	SOLIDS Susp.	SOLIDS Diss.	Total Phosphorus as PO_4	Nitrogen as N Free Ammonia	Nitrogen as N Total	pH	Hardness $CaCO_3$	Alkalinity $CaCO_3$	Dissolved oxygen Max.	Dissolved oxygen Min.	Total Coliforms per 100 ml.
A	3.1	2	186	0.41	0.16	0.84	8.5	138	127	7	7	28
B	4.6	17	291	1.00	0.82	1.06	8.1	240	226	9	7	890
C	2.5	10	196		0.20	0.92	8.6	146	132	4	4	50
D	2.7	1	217		0.16	0.96	8.5	144	132	7	0	8
E	1.3	3	183		0.15	0.64	8.3	144	127	5	5	84
F	2.0	1	185		0.13	0.65	8.4	144	126	6	5	68
G	1.1	1	207		0.15	0.59	8.4	144	128	6	2	8
H	1.5	1	209		0.15	0.58	8.5	144	127	7	6	176
I	0.7	2	200		0.16	0.79	8.0	148	130	3	0.6	8
J	1.3	4	204		0.15	0.79	8.5	144	127	7	4	40
K	1.6	2	204		0.13	0.59	8.6	144	126	7	6	60
L	1.1	2	206		0.15	0.64	8.6	144	127	8	6	96

Table 4. Stoco Lake

Sta.	BOD_5	SOLIDS Susp.	SOLIDS Diss.	Total Phosphorus as PO_4	Nitrogen as N: Free Ammonia	Nitrogen as N: Total	pH	Hardness $CaCO_3$	Alkalinity $CaCO_3$	Dissolved oxygen Max.	Dissolved oxygen Min.	Total Coliforms per 100 ml.
A	-	-	-	-	-	-	-	-	-	-	-	
B	-	-	-	-	-	-	-	-	-	-	-	7,000
C	1.2	8	132	0.29	0.26	0.70	7.8	68	58	-	-	11,000
D	0.4	4	112	0.30	0.33	0.77	7.8	68	58	5	0	9,000
F	0.4	14	100	0.27	0.36	0.91	7.8	80	69	7	4	3,300
1	-	-	-	-	-	-	-	-	-	8	7	-
3	1.2	6	106	0.25	0.26	0.75	7.9	80	67	-	-	2,200
5	1.1	7	109	0.39	0.39	0.96	7.4	86	77	5	5	-
7	1.1	3	81	0.14	0.23	0.78	7.9	86	77	7	0.2	810
10	1.4	6	122	0.32	0.39	0.83	7.9	80	70	7	6	-
										7	6	750

APPENDIX B

Results of chemical and bacteriological analyses of water samples collected from Moira River, Moira Lake, Stoco Lake and Tributaries, August, 1967. (Results are expressed as ppm except for pH and as otherwise noted.)

Table 1	Moira River
Table 2	Tributaries
Table 3	Moira Lake
Table 4	Stoco Lake

	DATE DUE		